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Conversion of Tibetan grasslands to croplands decreases accumulation of microbially synthesized compounds in soil

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ABSTRACT

Conversion of grassland to cropland affects microbial transformation of plant derived organic substances and the accumulation of microbially synthesized products in soil. We investigated long-term effects of agricultural use [more than 50 years' rotation with barley (*Hordeum vulgare*) and rapeseed (*Brassica rapa*)] after conversion from grasslands (grazed in the winter season) on the contents and composition of non-cellulose sugars and amino sugars in a broad range of soils on the Tibetan Plateau. Soils from two types of croplands (barley or rapeseed) were compared to a reference grassland soil by detailed analysis of plant vs. microbial and bacterial vs. fungal biomarkers. Long-term cultivation decreased total soil organic matter (SOM), light SOM and total non-cellulose sugar contents in the 0–20 cm soil by 27%, 47–72% and 57%, respectively, reflecting decreased root biomass compared to grassland. The ratios of (galactose + mannose)/(arabinose + xylose) and (rhamnose + fucose)/(arabinose + xylose) were both 26% smaller in cropland than in grassland soils, while the ratios of hemicelluloses in shoots or roots were similar between native and cultivated plants. Consequently, net transformation of plant substances to microbially synthesized polysaccharides decreased in cultivated soils. The total amino sugars (muramic acid, glucosamine, mannosamine, galactosamine) in cropland soils decreased by 42% as did their contribution to the SOM pool by 22%, compared to grassland soils, but the ratio of glucosamine/muramic acid in cropland soils doubled when compared to the grassland soil. This shows a strong decrease in microbial residue under cultivation, with the magnitude of the decrease greater in the bacterial than in the fungal components. All the above results from the intensively sampled site were confirmed in seven other sites featuring lower sampling intensity. We concluded that the conversion of grassland to cropland strongly decreases microbial transformation of plant residues and accumulation of the resulting microbial compounds – necromass – in soil (i.e., reduction of microbial input to stable SOM). The conversion also leads to a shift in the composition of microbial compounds towards a decreasing contribution of bacterial compared to fungal necromass.

1. Introduction

Conversion of native vegetation to croplands usually decreases soil organic matter (SOM) storage. This decrease in the SOM pool during cultivation is ascribed to accelerated mineralization (Huggins et al., 1998; Six et al., 1998; Lobe et al., 2001; Lal, 2002; Zingore et al., 2005) and lower plant residue input. Tillage disturbances destroy the physical protection of SOM (through adsorption on mineral surfaces and occlusion in aggregates), leading to better SOM accessibility to microorganisms. This mechanistic explanation is mainly deduced from reduced preservation of plant residue dominated particulate or/and light fraction SOM during decomposition compared to soils under native vegetation (Besnard et al., 1996; Lobe et al., 2002; Zingore et al., 2005; Lützow et al., 2006). Numerous studies, however, have demonstrated by physical fractionation (e.g., Lobe et al., 2001; Li et al., 2007; Shi et al., 2010) that, besides the depletion of plant-dominated SOM fractions by cultivation, mineral-associated SOM is also decreased when compared to native soils. This implies that the portion of litter that is incorporated into the stable SOM pool also decreases along with the stimulated decomposition under cultivation. The mineral-associated SOM pool that accounts for most SOM (Lützow et al., 2007) contains more microbially recycled components than the light SOM fractions (Lützow et al., 2006; Clemente et al., 2011). Therefore, conversion of native vegetation to cropland may affect microbial transformation of plant substances and accumulation of microbially synthesized products in soil.

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